

# Standardization of the Spacecraft Onboard Interface (SOIF)

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# Outline

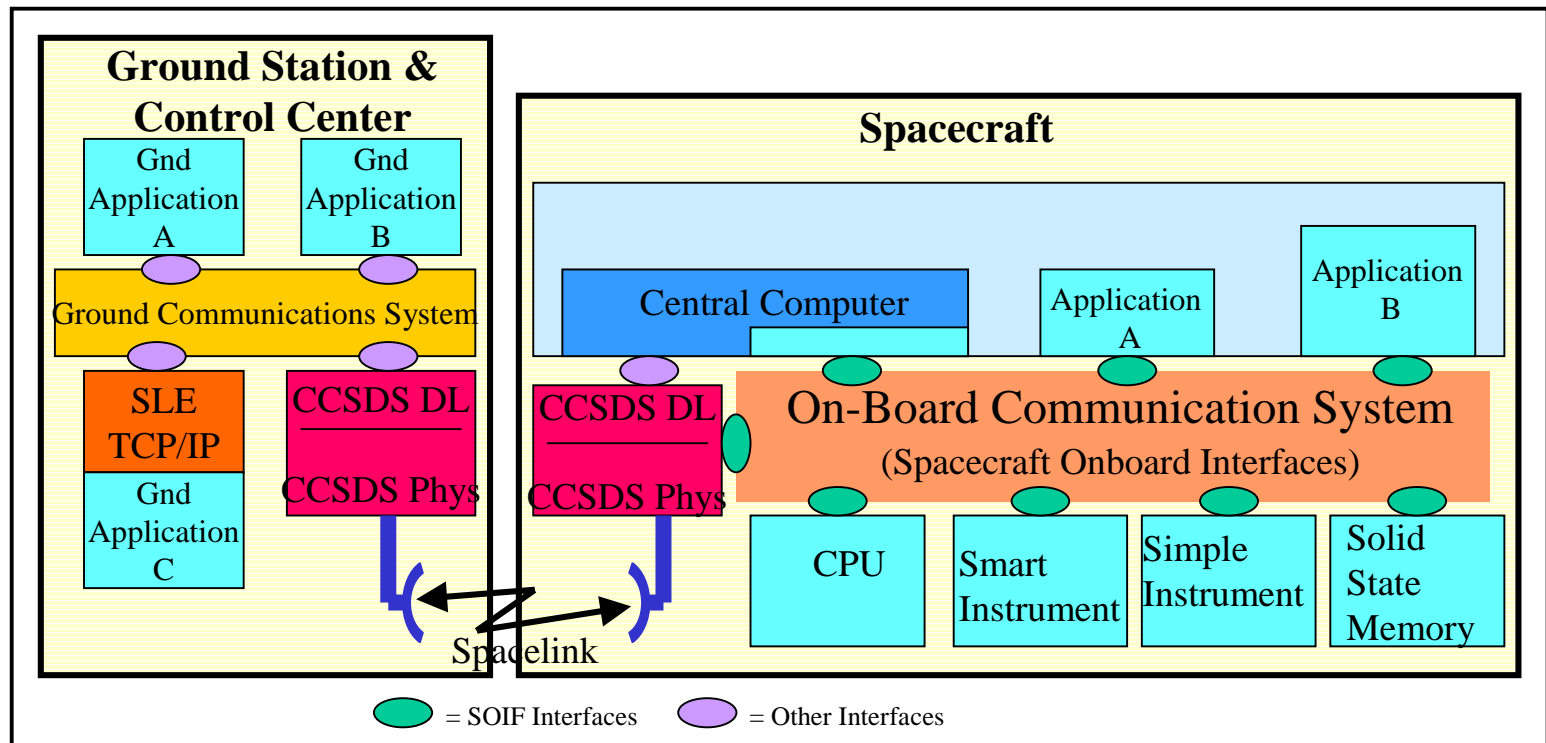
- Introduction to SOIF, Context, and Scope
- The Use of Standards
- SOIF Reference Model & Layers
- SOIF Services
- Changing the Data Bus
- Advantages of SOIF
- Building a Spacecraft
- Subsystem/Payload Perspective to Interfaces
- Conclusions
- The SOIF Timeline

# Introduction

- The Consultative Committee for Space Data Systems (CCSDS) is an organization of national space agencies cooperating in the development of data standards to promote interchange of space related information.
- CCSDS has started a new subpanel (1K) in order to look at what is needed for standardization of Spacecraft Onboard Interfaces (SOIF), starting with data bus (network) standards
- The most important aspect of the work is to determine methods that will allow easier substitution of data busses for onboard equipment, and applications, and a reduction of wires to sensors/actuators
  - Allow a significant reduction in wiring mass by putting sensors/actuators on a data bus
  - Will ease effort of moving between different implementations and upgrading to new busses and networks as technology changes
  - Would allow for ordered upgrade in equipment and applications over time
- Also looking at network services, standard communications services, and standard applications interfaces

# End-to-End Communications Context

- SOIF reference model fits in the end-to-end context of the CCSDS model
- SOIF and CCSDS end-to-end protocols are independent

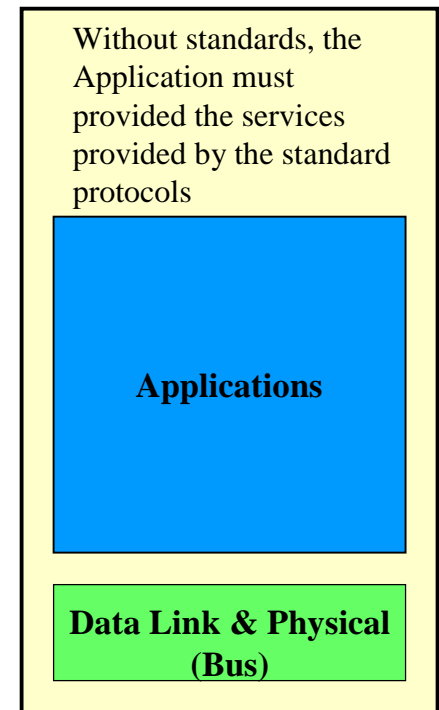
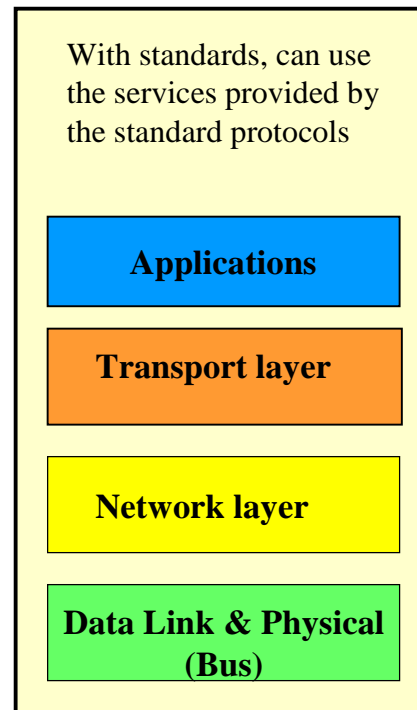


## Scope of SOIF

- One standard should be applicable for all mission types, there is no real difference in data bus for spacecraft, however there are some general trends
  - Deep space and commercial communications missions may have a need for longer life missions
  - Human inhabited (manned) missions may have requirements for on-orbit repair, replacement, reconfiguration
  - Earth observation missions may have requirements for high data rate
- Considering that SOIF work will be applicable for all classes of spacecraft devices, payloads, instruments, and subsystems
- Considering three speeds of interface to handle wide range of applications
  - Low-speed sensor and command/control busses: I<sup>2</sup>C
  - Medium-speed busses: Mil-Std-1553B and OBDH
  - High-speed busses: IEEE-1394 and SpaceWire

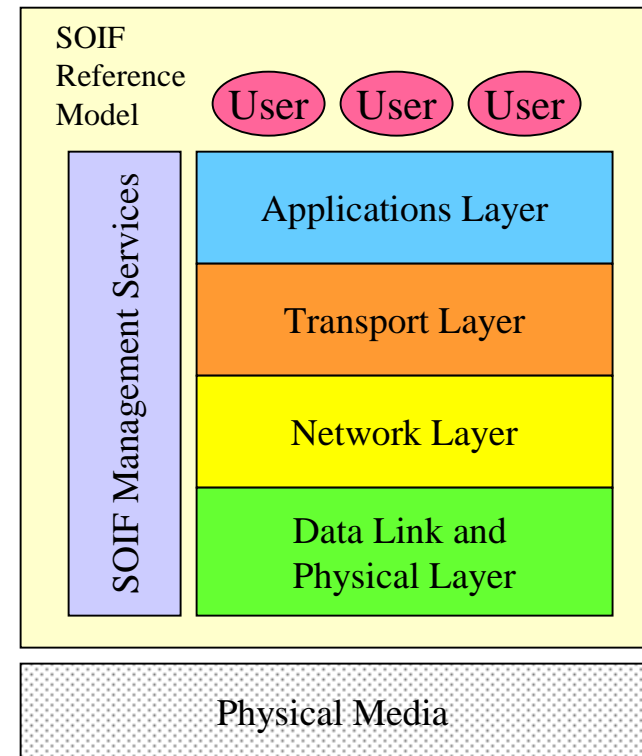
# Using Standards Vs. Not Using Standards

- When communications standards are used, then the application can use the services provided by the protocol
- Without communications standards, then the applications either need to supply the service themselves, or do without the service
- Without standards, when the underlying bus changes, then the effects will ripple up into the applications
- The use of layered standards should increase order and clarity, not increase complexity



# The SOIF Reference Model

- Application Layer contains user oriented services which are presented to the users
- Transport Layer provides end-to-end transport of messages between users
- Network Layer contains services to control of sub-network operation, & routing of data to location
- Data Link and Physical Layer contain communications services of the low level network, usually a standard



# Mapping of the SOIF Layers to OSI Layers

- Provides a mapping of the SOIF layers to the familiar OSI layers
- Presentation Layer services (if any) are included into the Application Layer
- No need for distinct Session Layer, so is mapped into the Transport Layer
- Network Layer provides these services
- Data Link and Physical Layers are combined into a single layer
  - This single layer demonstrates how underlying bus interfaces to rest of SOIF Reference Model
  - Can change out bus with change of this layer

Application Layer		Application Layer
		Presentation Layer
Transport Layer		Session Layer
		Transport Layer
Network Layer		Network Layer
Data Link and Physical Layer		Data Link Layer
		Physical Layer

**SOIF Layers**

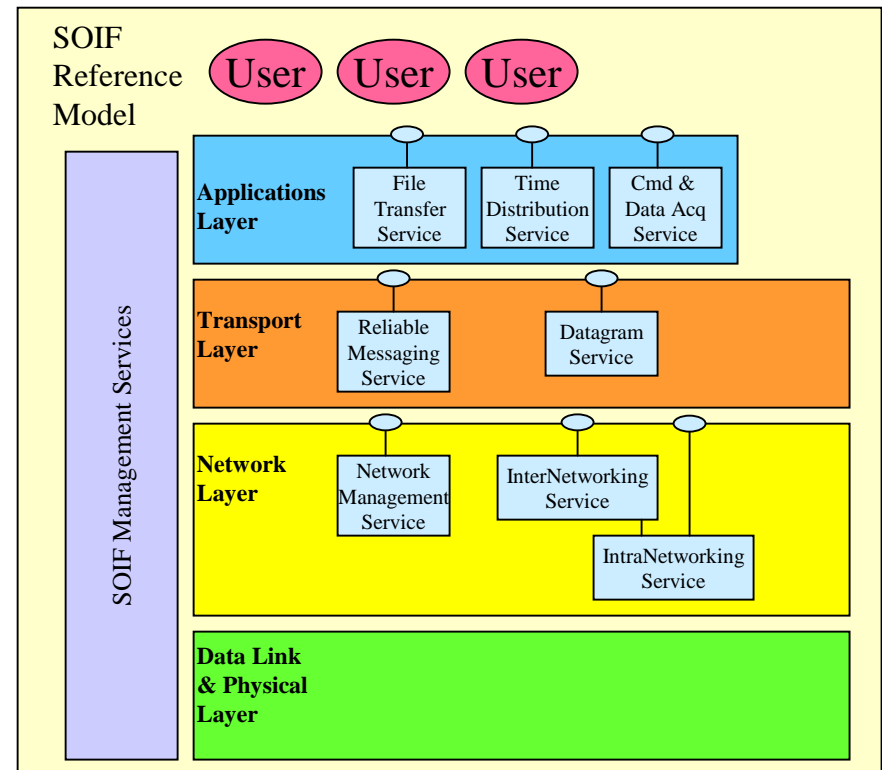
**OSI Layers**

**Mapping of the SOIF Layers to the ISO OSI Layers**



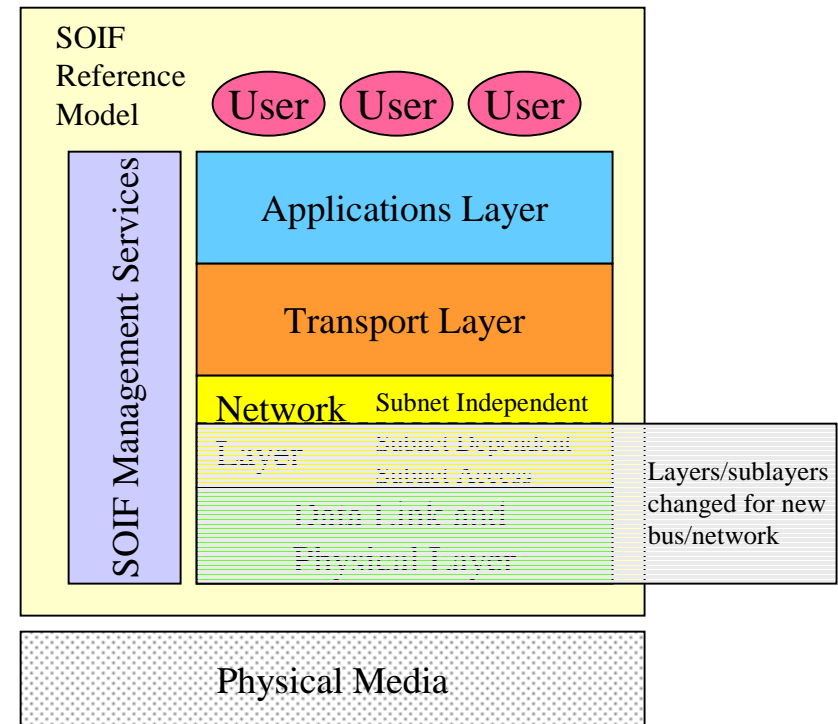
# SOIF Services Exposed to Users

- Application Layer Services
  - File Transfer for reliable transfer of files
  - Time Distribution for coherent time information to users
  - Command and Data Acquisition service for minimal latency for simple devices
- Transport Layer Services
  - Reliable Messaging Service for guaranteed delivery
  - Datagram Service for non-guaranteed delivery
  - Network Management
- Network Layer Services
  - Internetworking Service provide connection to other networks
  - Intranetworking for connection to same network (subnet)



# Changing the Data Bus or Network

- SOIF also will allow easier changeout from one type of data bus or network to another
- Changes will be confined to the Data Link and Physical Layers (with media) and the two lower sub-layers of the Network Layer
- Elements of the Network Layer that are independent of the underlying bus/network are not changed
  - Routing/Addressing outside of the subnet
- Elements of the Network Layer that are dependent on the underlying bus/network are changed
  - Routing/Addressing within the subnet



- Means that we can change out the underlying bus without effecting the users and upper layers

## Advantages of SOIF: Why We Need SOIF

- The SOIF concepts will de-couple the user application (software) from the spacecraft hardware, allowing greater reuse
  - The application software isn't dependent on the data bus implementation
  - Allows greater use of software drivers for hardware interface, to de-couple the applications from the hardware devices (sensors and actuators)
- Will ease the ability to reuse hardware with different data busses, therefore with different spacecraft
  - Hardware devices, subsystems, instruments, payloads
  - Changing the data bus will only effect the interface, and not the application or the device's functionality
- SOIF will facilitate the migration of engineering sensors and actuators from dedicated wires onto a data bus
  - This will enable greater access to the engineering data, and reduce wiring mass
  - Will also enable later migration to wireless technologies for these devices if practicable

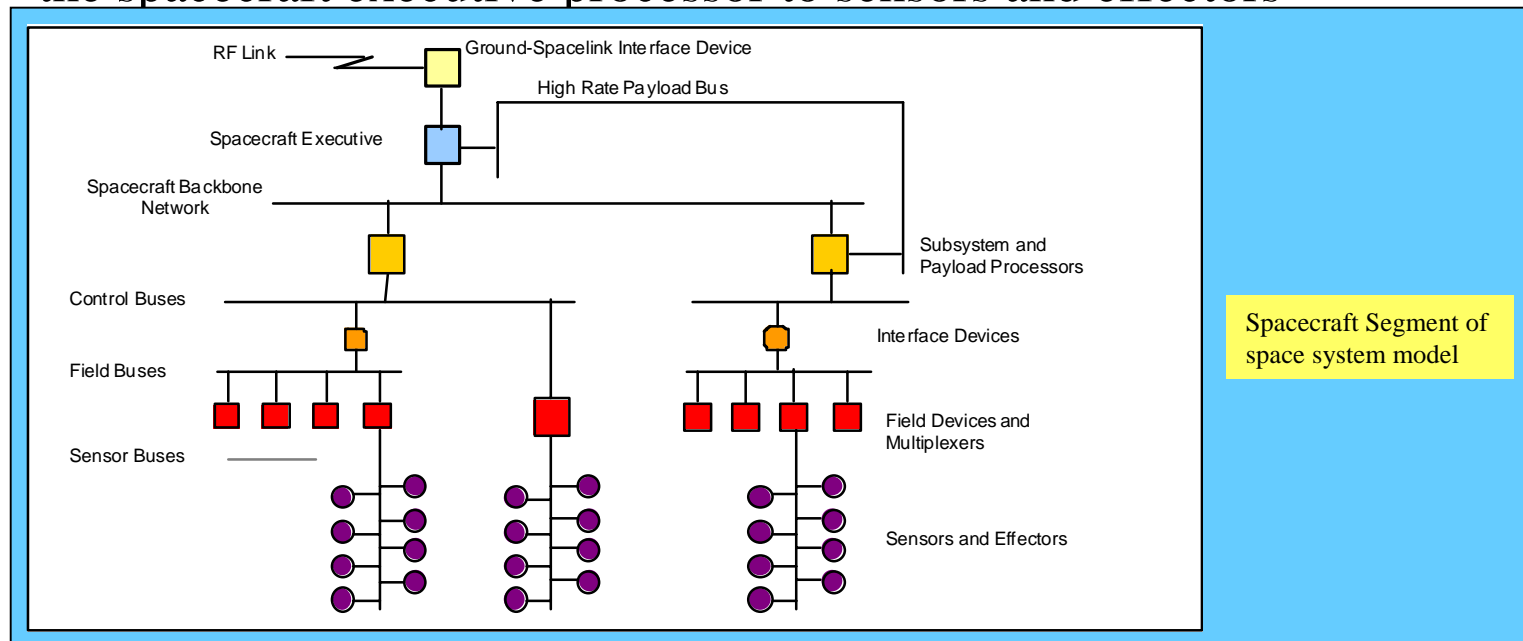
# How We Build Spacecraft

- As spacecraft engineers, we have two (conflicting?) desires
  - To build the best (neatest) spacecraft with the “appropriate” (neatest) technology
  - To build a spacecraft that will do the job and meets schedule and budget
- Program Managers like the engineers to meet the schedule and budget
- Would be nice to use COTS interfaces for spacecraft, but commercial busses usually don’t meet all requirements (usually reliability and/or environment) and carry “extra” functionality
  - Can give us some real savings with larger user base, and test equipment
  - Can modify the bus to meet the requirements, but then it isn’t COTS any more

- **A basic assumption to this discussion is that the best way to stay within the budget is to meet the schedule**

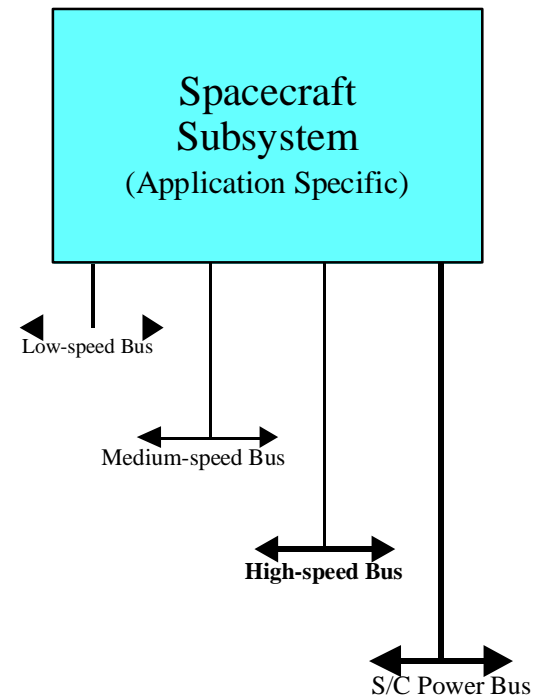
# A Spacecraft Data System Hierarchy

- Spacecraft segment can be modeled with various levels of busses, each with a different level of responsibility for running the spacecraft systems
- Devices interfacing to the busses vary from high speed payloads and the spacecraft executive processor to sensors and effectors



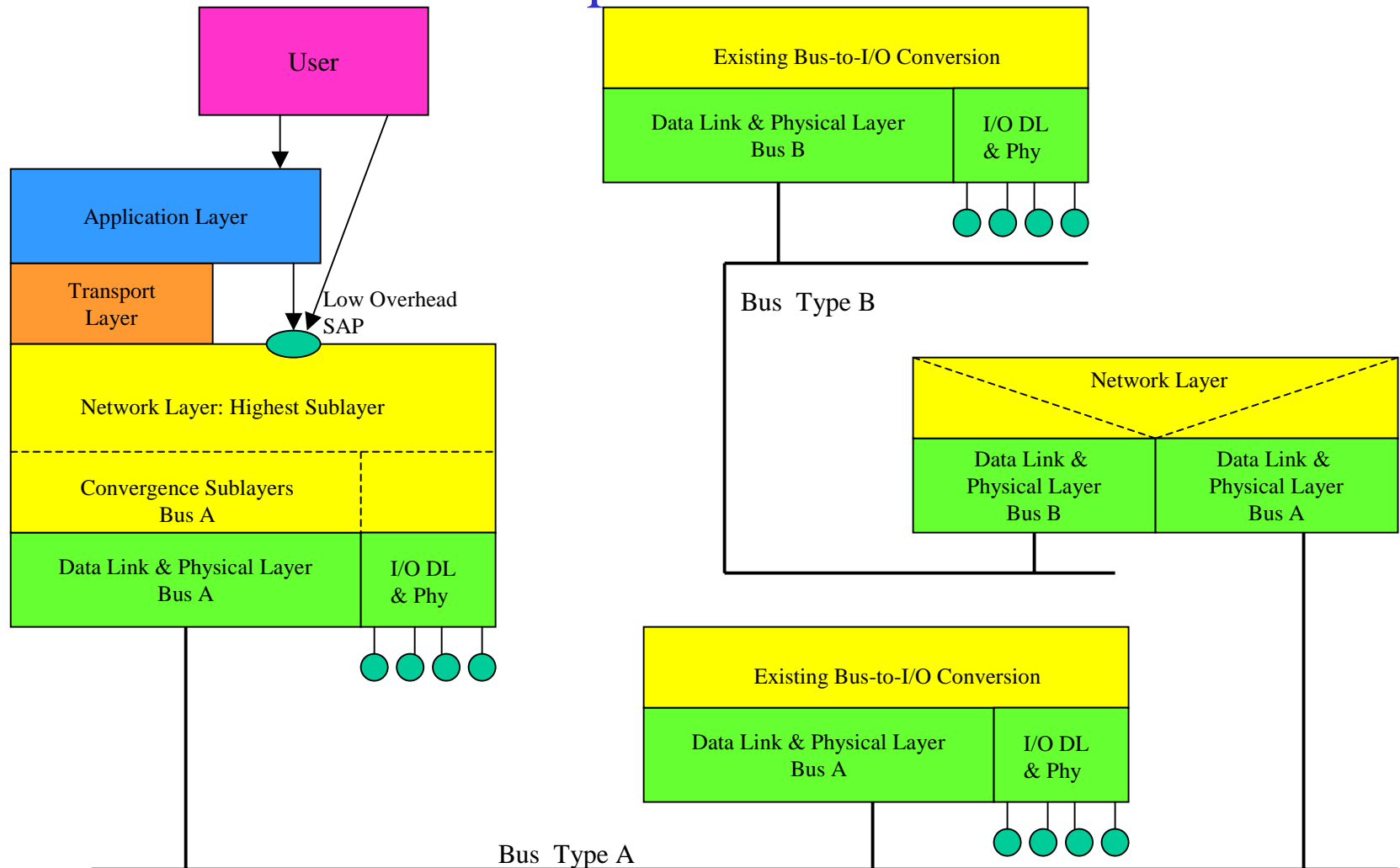
# The Subsystem or Payload Perspective

- From the perspective of the instrument or subsystem
  - all external electrical interfaces can be met with the set of standardized interfaces
  - Power standard selected for spacecraft & instrument/subsystem needs
  - Use of high-, medium-, and/or low-speed busses meet all instrument/subsystem needs, using one or more of the three selected busses
- Only standardized interfaces are to be tested during vehicle integration & test, placing all unique I/Fs (if used) inside instrument/subsystem



Subsystem/Instrument perspective  
Of the SOIF implementation

# Three Cases of the Low Overhead Interface to Simple Devices



## Towards Some Conclusions

- What we usually do is to create a number subsystems or instruments/payloads
  - Each subsystem or instrument will be have its own data bus physical domain
  - This domain is good, in that it we will wind up integrating subsystems and instruments instead of individual devices
  - This simplifies the interfaces, and puts hard work (systems engineering and integration & test) on the subsystem engineer (minimal schedule theory)
- This is an excellent method for most spacecraft and space vehicles
- But remember, the SOIF architecture is now allowing us nearly transparent access to devices and subsystems anywhere on the vehicle



## And Some Conclusions

- Can organize the vehicle avionics by any convenient parameter
  - Can be by subsystem/instrument
  - Can be by physical element
    - Main body
    - Scan Platform
    - Communications package/Antenna
    - Propulsion Module
  - Can be by launch element
  - Can be by most any parameter that we may wish
- Once we learn to build, test, and trust these systems, will give us another level of freedom in spacecraft avionics design

## The SOIF Timeline

- Presently SOIF is in a phase where we are working both on Standards Research, and Standards Development
- CCSDS SOIF schedule
  - Presently working of first released draft of White Book, due in November 2001
  - Final late version Red Book (draft) in the second half of 2002
  - Approved final standard (Blue Book) scheduled for late 2003
- If CCSDS Subpanel 1K keeps to this schedule, then will be able to start implementations in 2002, with no expected changes after mid 2003
- Participation is invited